years we issued a little "length of service" pamphlet and a list of the veterans is published once each year in Climatological Data. Copies of Tycos and the Bulletin of the American Meteorological Society are passed about among the observers and publications are sometimes secured from the central office for distribution.

And so it is seen that hearty cooperation is necessary in the successful conduct of a climatological service and personal contact is probably the most important element in attaining that cooperation.

ARE PRESENT METHODS IN COOPERATIVE CLIMATOLOGICAL WORK EFFECTUAL?

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Some difficulty was experienced in choosing for this brief paper a title that would indicate exactly the things the writer had in mind to discuss; and since the title was submitted some doubt has remained in his mind as to whether it carries his meaning. Therefore, at the outset permit him to say that there is no intention of reflecting upon the character of the service rendered by the cooperative observer, nor in any manner whatever of impeaching his weather record. His importance in the field of climatology, and his public spiritedness and devotion to duty without compensation, oftentimes under trying circumstances, are highly appreciated by the great body of investigators who reap the benefit of his labors, but are appreciated by none more than by the officials of the Weather Bureau so closely in contact with his work. Nevertheless, in passing it may be said that the cooperative observer par excellence is, at least in some sections, becoming more and more a rara avis, and consequently the maintenance of satisfactory cooperative weather stations in such sections is becoming likewise more and more difficult. This is especially true of the more populous and urban regions. This situation was recognized by the director of the Iowa climatological section, and was commented on by him in his report for January, 1928. It has also been the experience of the writer in his work in the Indiana climatological section. The causes, however, have nothing to do with the purpose of this paper, and may, therefore, be left for possible future consideration.

As there is no intention of reflecting on the work of the cooperative observer, also neither is there any intention of intimating that the presentation of climatological data as published by the Weather Bureau in its several section monthlies is of other than very great value to the bureau itself as well as to many and varied interests and professions. The ever increasing demand for such data by these industries and professions is proof positive of the important service performed in securing and distributing climatological information.

However, if there be in the observations, records, and subsequent publications, any matters that may be more accurately interpreted, or presented to better advantage, such matters, even though of minor importance are worthy of some consideration. In the course of nearly 20 years of practice in the inspection of cooperative climatological data and of preparing the same for publication there have arisen in the mind of the writer two general questions, each with several separate divisions:

(*1*) As to whether in the inspection and final summarizing of cooperative records at the section center certain corrections or adjustments before publication are desirable; and,

(*2*) As to whether the climatological data presented in the printed section monthlies could to advantage be curtailed, added to, or changed in any respect.

As to the first of these general questions, extended comparison of Indiana cooperative data with those of the regular Weather Bureau stations within and near the section boundaries, as well as similar though less extended comparisons of the data in other sections, has lead to the following conclusions, which are submitted with some comment thereon:

(*a*) That for much of the country, cooperative records usually average a greater number of days with maximum temperatures of 90° and higher, and also a greater number of days with minimum temperatures of 32° and lower, than do the records of the regular Weather Bureau stations in and around the same section. Why is this and what is the effect, if any, upon the mean temperature computed for the section?

It will be recalled that the meteorological day at the cooperative station usually ends at some afternoon hour near sunset or earlier, and that the temperature readings then obtained are for the preceding 24 hours. As the highest temperature of the day occurs most frequently during the early to late afternoon, it is naturally to be expected that days of any maximum temperature chosen for count will be recorded in greater number at the cooperative station than will be the case at the regular Weather Bureau station where the day closes at midnight. In other words, the maximum temperature of a single calendar day, by reason of the fact that it usually occurs in the afternoon, is often carried into the cooperative record as the maximum temperature of two days instead of one; so increasing the total number of days of certain high temperatures, and also increasing slightly the mean maximum temperature computed for that particular month.

The cause of the recorded larger number of days with minimum temperature of say 32° or lower at many cooperative stations—not so many more, however, as is the case with high temperature records—is different. Except at the comparatively few cooperative stations taking observations in the morning at about 7 a. m., the hour of the cooperative observation has little effect on the number of such days recorded. Most of the regular Weather Bureau stations are in the central business sections of the larger cities, where the minimum temperature that usually occurs during the late night or early morning is held up somewhat by the greater heat of large buildings and pavements, and by the effect of overhanging smoke in hindering radiation of heat. On the other hand, cooperative stations usually have a much more open exposure, and even if located in the large cities are most often to be found in the outlying residential sections. In such places the fall of temperature through the night to its minimum is not retarded by the conditions mentioned in the preceding sentence; and so, consequently, the cooperative station more often records a low temperature of say 32° or lower than does the regular Weather Bureau station.

As the greater number of days with high temperatures recorded at cooperative stations must result—and improperly so—in an erroneous idea of the frequency of such days in that locality, and a slightly higher mean monthly maximum temperature than should be the case,

so also does the greater number of days with low temperature of say 32° result—but properly so—in a lower mean monthly minimum temperature than is the case for the regular Weather Bureau stations in the same region. While these differences, as reflected in averages, are but slight, they should not be discarded from consideration, and the question arises as to whether it may not be practicable and advisable for the reviewing officials at the section centers to adjust cooperative temperature records to the midnight to midnight basis by a careful comparison of the hourly trend of temperature as shown by the thermograph traces of the Weather Bureau stations in and around the section. It is believed that this matter is worthy of study and experimental tests in practically all of the climatological sections of the country.

(*b*) Cooperative station records usually average a smaller number of days with precipitation of the amount of 0.01 inch or more as compared with the records of regular Weather Bureau stations in and around the same region. A study of the hourly precipitation records of the Indianapolis station of the Weather Bureau, and a previous study of similar data of the Chicago station covering a period of 10 years, has shown that on the whole precipitation in the region of those two stations occurs more frequently during the afternoon hours than it does at midnight. It might be expected that, as a natural result, the measurement of precipitation at any afternoon hour of observation, say 5 p. m., would more often give measureable amounts of 0.01 inch or more on both sides of the hour than would be the case were the observation made at midnight. In other words, it is apparently reasonable to expect that in the case of an observation made in the late afternoon a single rainfall will often appear in the record as two days of rain; whereas a fewer number of days with rain would appear if the observation were made at midnight. This reasoning would lead us to the conclusion that cooperative records average a larger number of days with 0.01 inch or more precipitation than the records of regular Weather Bureau stations, and it is rather astonishing to find that such is not the case.

For instance, in the records of 1926, the climatological section of Arkansas from its complete list of cooperative and Weather Bureau stations averaged 88 so-called rainy days, while the average to be obtained from the records of the regular Weather Bureau stations in and near the borders of Arkansas is 106, a greater number by 18 rainy days; Texas from its complete list averaged 70 rainy days, while its Weather Bureau list averaged 94, greater by 24 rainy days; lower Michigan from its complete list averaged 115 rainy days, while its Weather Bureau list averaged 153, greater by 38 rainy days; New England from its complete list averaged 127 rainy days, while its Weather Bureau list averaged 134, greater by 7 rainy days; Virginia from its complete list averaged 102 rainy days, while its Weather Bureau list averaged 128, greater by 26 rainy days; Wyoming from its complete list averaged 76 rainy days, while its Weather Bureau list averaged 110, greater by 34 rainy days; eastern Washington from its complete list averaged 84 rainy days, while its Weather Bureau list averaged 89, greater by 5 rainy days; western Washington from its complete list averaged 152 rainy says, while its Weather Bureau list averaged 163, greater by 11 rainy days.

Similar results were obtained from the records of other years and other sections, so that it apparently is the rule that precipitation is less frequent as reflected by the cooperative records than as reflected by the records of regular Weather Bureau stations, notwithstanding any effect that might be expected from the differing 24-hour periods for which the measurements are made. The writer has no explanation to offer, but submits the fact as one needing careful study by the several section officials with the view of determining what adjustments, if any, are practicable in the interest of consistency.

(*c*) Cooperative records usually average a smaller number of days called "partly cloudy" as compared with the records of regular Weather Bureau stations of the same region, the difference being accounted for in the recorded number of clear or of cloudy days. In this connection it is proper to observe that cooperative observers, although conscientious in the performance of their duties as such, are yet mostly very busy persons, absorbed throughout the day in close attention to the needs of an exacting business, oftentimes indoors. Observations of the condition of the sky may therefore be necessarily infrequent; and as a result the judgment as to the character of the day may be based more or less upon the early morning or late afternoon observation than upon several scannings made during the course of the day. In this connection the question arises whether it would not be better if the cooperative observer so situated recorded only the condition of cloudiness at the actual time of his observation, indicating his record as such, permitting the records of the regular Weather Bureau stations to indicate the general character of the daytime hours over the section.

As to the second general question mentioned in the first part of this paper—as to whether the climatological data presented in the printed section monthlies could to advantage be curtailed, added to, or changed in any respect—experience during nearly 30 years in answering requests for climatological data has led to the following conclusions:

(*a*) That there is no demand for, and practically no use for, data on greatest daily range in temperature as printed in the monthly section reports in the general table on the second page of each, and that some other useful data might therefore be substituted to advantage. These greatest daily ranges as printed are computed from the maximum and minimum temperatures in a 24-hour period that does not usually coincide with the calendar day, except in the case of the regular Weather Bureau stations and a very few others. The ranges so obtained, particularly during long periods of rising or falling temperature, often do not approximate even closely the true daily ranges; and especially is this the case of cooperative records based on morning observations, of which most climatological sections have some number.

(*b*) That the mean monthly temperatures shown in the same general table for the several stations do not furnish sufficient information as to the general temperature characteristics of the month. The same station may have the same mean monthly temperature in two or more years—or two different stations may have the same mean monthly temperature in the same year—and yet the fluctuations of temperature from day to night be totally different for any two compared. However, if instead of the greatest daily range mentioned in the preceding paragraph, the mean daily range were printed, that item would furnish good information on which to base comparisons from month to month, and from station to station, because one-half of the mean range added to and subtracted from the mean monthly temperature gives the mean maximum and the mean minimum temperature to a sufficiently accurate degree.

(c) That, while division and section mean monthly temperatures are of some value for purposes of comparison in more or less level areas, they are of little use for that purpose in many rugged or mountainous regions. However, mean monthly temperatures in such rugged regions, if arranged and averaged by elevations, may serve many useful purposes, and tend to establish practically the effect of altitude on temperature, just as in the more level areas north to south division mean temperatures establish the variation due to latitude.

For instance, in the published climatological data for Colorado for April, 1927, there is no separation of the State into smaller divisions, but cooperative and other stations are arranged alphabetically in one list. The mean temperature for the entire State was computed from the several mean temperatures in this list by averaging them in one operation, and was found to be 44.2°.

If, however, we arrange stations and compute mean temperatures by altitudes from lowest to highest in several zones, say of 1,000 feet each, we have, beginning with the lowest zone, results as follows: 3,000 to 4,000 feet, 6 stations, mean temperature, 52.1°; 4,000 to 5,000 feet, 16 stations, mean temperature, 49.9°; 5,000 to 6,000 feet, 13 stations, mean temperature, 48.6°; 6,000 to 7,000 feet, 14 stations, mean temperature, 44.5°; 7,000 to 8,000 feet, 8 stations, mean temperature, 40.3°; 8,000 to 9,000 feet, 11 stations, mean temperature, 36.0°; 9,000 to 10,000 feet, 4 stations, mean temperature, 35.5°; 10,000 feet and higher, 4 stations, mean temperature, 33.2°.

This arrangement and averaging shows a more or less gradual drop in mean temperature from the lower to the higher zones. The average altitude computed from the elevations of the entire number of stations in the list is 6,416 feet, which falls in the 6,000 to 7,000 foot zone, the mean temperature of which, as obtained above, is 44.5°, only 0.3° higher than the mean temperature for the State (44.2°) as printed. Similar results have been secured from the data for other mountain States.

(d) That, while the demand for climatological data is constantly growing, and while inquiries are ever increasing in variety, response to which requires more and more time for special compilation, the limits of the publication have remained practically constant for more than a decade. The need for more detailed data on storm damage alone would frequently justify the extension of the printed matter by practically a page; and if we could insert in this publication data to answer inquiries regarding frequency of rainfalls and snowfalls of stated amounts, river stages and flood conditions, more complete information as to the effect of weather on crops, etc., still another page would be none too much.

Such questions as those briefly discussed in this paper, together with many others, some general, some pertinent to individual sections, are the problems of the Weather Bureau section director in serving the public interest. Their consideration, it is believed, should receive the attention of more than the individual official in his section; and in conclusion the writer begs leave to express the hope that at some time in the future it may be found practicable for the officials in charge of the climatological work of the bureau, both at the central office and in the field, to congregate from time to time to discuss in body these and similar questions, and to provide as far as practicable uniform and increasingly effectual methods of handling and publishing these valuable records of the cooperative climatological service.

FOREST-TREE DISEASES CAUSED BY METEOROLOGICAL CONDITIONS [1]

By ERNEST E. HUBERT, Professor of Forestry
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When crops are poor, when epidemics of human disease are prevalent, or when forest fires rage over a wide territory, we are constantly reminded "It's the weather." The weather appears to be held responsible for many things, including rheumatism and the irregularities in the yearly growth of trees. Now come the forest pathologists to fill the cup to overflowing by stating quite calmly that meteorological conditions are responsible for a considerable number of important tree diseases. Fortunately, many of these diseases are of minor importance economically and do not greatly affect the life of a stand of timber. Others, however, cause considerable loss.

In a discussion of tree diseases, it is always helpful to group them under two main heads—(1) diseases caused by organic agencies such as fungi and mistletoes and (2) diseases caused by physiogenic agencies such as heat, frost, wind, and similar physical causes. The physiogenic diseases include all causes of disease which are produced by various atmospheric changes and disturbances, as follows: Sunscald, drought, wilting, frost cracks, frost heaving, frost bite, wind breakage, wind throw, wind deformation, red belt, sun scorch, too much or too little light, lightning injury, ice injury (sleet storms), snow breakage, snow smothering, snow heating, subsnow fungi, root suffocation (too much rain), gas injury, and dust injury.

FROST INJURY

Much has already been written on the cause and control of frost injury brought about by low temperature. In the literature are to be found several types of frost injury designated by various terms. Early and late frost injury, discoloration, wrinkling, slitting of leaves, and frost cracks are common injuries which result from the effects of direct freezing. Other types of injury such as "red belt" and a closely related one which may be aptly termed "sun scorch" or "sun burn" appear to be caused primarily by low temperatures but require the action of meteorological factors other than frost to bring about actual damage and the accompanying symptoms.

Frost injury in one form or another is fairly common in all regions where the temperatures fall below the freezing point of water. In the colder climates severe injury frequently occurs in seedling stock grown in forest nurseries and to transplanted stock. In the forested regions certain areas are known as frost pockets or frost centers in which frost injury is apparently more prevalent than in the adjacent areas. Topography and exposure are factors of importance which may account for such areas. Sun scorch and red-belt injury are confined to the coniferous forests and are most commonly, if not exclusively, reported occurring in the western coniferous belt.

Wilting takes place after severe frost injury and is followed by discoloration of the leaves and later on by a water-soaked appearance of the tissues. In some species the young bark turns a dark color. Tender tips and stems and young leaves are most susceptible and for this reason nursery stock often suffers severely.

Another common symptom of frost injury is the well-known frost crack or frost split which occurs in the trunks of some of our forest and ornamental trees. These radial

[1] Presented before the American Meteorological Society, Pacific Division of the A. A. A. S., Eugene, Oreg., June 20, 1930.